UNIVERSITÉ DE SHERBROOKE

Faculté d'éducation

L'effet de l'utilisation des exercices de devoirs en ligne sur le rendement des élèves dans un cours de Méthodes quantitatives

The Effect of Using Online Homework Exercises on Student Achievement in a Quantitative Methods Course

Par

Marc Bélanger

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a été évalué par un jury composé des personnes suivantes :

Dr. Shernaz Choksi First name and Last name	Research Supervisor
Dr. Sawsen Lakhal First name and Last name	External Evaluator of the Master's Paper

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SUMMARY

Quantitative Methods (QM) is a compulsory course in the Social Science program in CEGEP. Many QM instructors assign a number of homework exercises to give students the opportunity to practice the statistical methods, which enhances their learning. However, traditional written exercises have two significant disadvantages. The first is that the feedback process is often very slow. The second disadvantage is that written exercises can generate a large amount of correcting for the instructor.

WeBWorK is an open-source system that allows instructors to write exercises which students answer online. Although originally designed to write exercises for math and science students, WeBWorK programming allows for the creation of a variety of questions which can be used in the Quantitative Methods course. Because many statistical exercises generate objective and quantitative answers, the system is able to instantly assess students' responses and tell them whether they are right or wrong. This immediate feedback has been shown to be theoretically conducive to positive learning outcomes. In addition, the system can be set up to allow students to re-try the problem if they got it wrong. This has benefits both in terms of student motivation and reinforcing learning.

Through the use of a quasi-experiment, this research project measured and analysed the effects of using WeBWorK exercises in the Quantitative Methods course at Vanier College. Three specific research questions were addressed. First, we looked at whether students who did the WeBWorK exercises got better grades than students who did written exercises. Second, we looked at whether students who completed more of the WeBWorK exercises got better grades than students who completed fewer of the WeBWorK exercises. Finally, we used a self-report survey to find out what students' perceptions and opinions were of the WeBWorK and the written exercises.

For the first research question, a crossover design was used in order to compare whether the group that did WeBWorK problems during one unit would score significantly higher on that unit test than the other group that did the written problems. We found no significant difference in grades between students who did the WeBWorK exercises and students who did the written exercises.

The second research question looked at whether students who completed more of the WeBWorK exercises would get significantly higher grades than students who completed fewer of the WeBWorK exercises. The straight-line relationship between number of WeBWorK exercises completed and grades was positive in both groups. However, the correlation coefficients for these two variables showed no real pattern.

Our third research question was investigated by using a survey to elicit students' perceptions and opinions regarding the WeBWorK and written exercises. Students reported no difference in the amount of effort put into completing each type of exercise. Students were also asked to rate each type of exercise along six dimensions and a composite score was calculated. Overall, students gave a significantly higher score to the written exercises, and reported that they found the written exercises were better for understanding the basic statistical concepts and for learning the basic statistical methods. However, when presented with the choice of having only written or only WeBWorK exercises, slightly more students preferred or strongly preferred having only WeBWorK exercises.

The results of this research suggest that the advantages of using WeBWorK to teach Quantitative Methods are variable. The WeBWorK system offers immediate feedback, which often seems to motivate students to try again if they do not have the correct answer. However, this does not necessarily translate into better performance on the written tests and on the final exam. What has been learned is that the WeBWorK system can be used by interested instructors to enhance student learning in the Quantitative Methods course. Further research may examine more specifically how this system can be used more effectively.

RÉSUMÉ

Méthodes quantitatives est un cours obligatoire dans le programme de sciences humaines au CEGEP. La plupart des instructeurs donnent un certain nombre d'exercices de devoirs aux étudiants pour donner la possibilité de pratiquer les méthodes statistiques, ce qui améliore leur apprentissage. Toutefois, des exercices écrits traditionnels ont deux inconvénients importants. Le premier est que le processus de correction et de rétroaction est souvent très lent. Le deuxième inconvénient est que les exercices écrits peuvent générer une grande quantité de correction pour l'instructeur.

WeBWorK est un système code source ouvert (open source) qui permet aux instructeurs d'écrire des exercices dont les étudiants répondent en ligne. Conçu à l'origine pour les étudiants en mathématiques et en sciences de la nature, la programmation de WeBWorK permet la création d'une variété de questions qui peuvent être utilisés dans le cadre des méthodes quantitatives. Parce que de nombreux exercices dans les statistiques engendrent des réponses objectives et quantitatives, le système est en mesure d'évaluer instantanément les réponses des élèves et de leur dire s'ils ont tort ou raison. Cette rétroaction immédiate a été démontré théoriquement propice à la réussite de l'apprentissage. Aussi, le système peut être programmé pour permettre aux élèves de réessayer le problème s'ils se sont trompés. Cela présente des avantages à la fois en termes de motivation des élèves et en termes de renforcer l'apprentissage.

Grâce à l'utilisation d'une quasi-expérience, ce projet de recherche a mesuré et analysé les effets de l'utilisation des exercices de WeBWorK dans un cours de Méthodes quantitatives au Collège Vanier. Trois questions de recherche spécifiques ont été abordées. Tout d'abord, nous avons examiné si les étudiants qui ont fait les exercices de WeBWorK ont obtenu de meilleures notes que les élèves qui ont fait les exercices écrits. Deuxièmement, nous avons examiné si les étudiants qui ont complété plus des exercices de WeBWorK ont obtenu de meilleures notes que les étudiants qui ont complété moins des exercices de WeBWorK. Enfin, nous avons utilisé un questionnaire d'auto-évaluation pour déterminer les perceptions et les opinions des élèves vis-à-vis les exercices WeBWorK et les exercices écrits.

Pour la première question de recherche, un plan d'étude croisé (crossover design) a été utilisé afin de comparer si le groupe qui a fait des problèmes de WeBWorK pendant une unité d'apprentissage aurait des notes significativement plus élevés par rapport au groupe de référence qui a fait les problèmes écrits. Nous n'avons trouvé aucune différence significative entre les étudiants qui ont fait les exercices de WeBWorK et les étudiants qui ont fait les exercices écrits.

La deuxième question de recherche visait à déterminer si les étudiants qui ont complété plus des exercices de WeBWorK obtiendraient des notes beaucoup plus

élevées que les étudiants qui ont complété moins des exercices de WeBWorK. La relation linéaire entre le nombre d'exercices de WeBWorK complétés et les notes a été positive dans les deux groupes. Cependant, les coefficients de corrélation pour ces deux variables ne présentaient aucun motif perceptible. Dans l'ensemble, faire plus d'exercices de WeBWorK était positivement corrélée avec des notes plus élevés, mais cette relation était ni forte ni toujours statistiquement significative.

Notre troisième question de recherche a été étudiée en utilisant un sondage pour connaitre les perceptions et les opinions des étudiants concernant les exercices WeBWorK et les exercices écrits. Les étudiants n'ont rapporté aucune différence dans la quantité d'effort consacré à la réalisation de chaque type d'exercice. On a également demandé aux élèves d'évaluer chaque type d'exercice sur six dimensions et un score composite a été calculé. Dans l'ensemble, les élèves ont donné un score significativement plus élevé pour les exercices écrits, et ont indiqué qu'ils ont trouvé que les exercices écrits étaient mieux pour comprendre les concepts statistiques de base et pour apprendre les méthodes statistiques. Toutefois, lorsque présenté avec le choix d'avoir seulement des exercices écrit ou seulement des exercices de WeBWorK, légèrement plus d'étudiants ont préférés ou fortement préférés ayant seulement des exercices de WeBWorK.

Les résultats de cette étude suggèrent que les avantages de l'utiliser WeBWorK pour enseigner le cours Méthodes quantitatives sont variables. Le système de WeBWorK offre une rétroaction immédiate, ce qui motive les étudiants à essayer de nouveau s'ils n'ont pas la bonne réponse. Toutefois, cela ne se traduit pas nécessairement par de meilleures performances sur les épreuves écrites et à l'examen final. Qu'est-ce qui a été appris est que le système de WeBWorK peut être utilisé par des instructeurs intéressés pour améliorer l'apprentissage des élèves dans le cours de Méthodes quantitatives. D'autres recherches pourraient examiner plus précisément comment ce système peut être utilisé de manière plus efficace.

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LIST OF ABBREVIATIONS, INITIALISMS, AND ACRONYMS

QM	Quantitative Methods
CEGEP	Collège d'enseignement général et professionnel
SCL	Student-Centred Learning
HHS	High Homework Scorers
LHS	Low Homework Scorers
A13	Automne 2013, the Fall semester
H14	Hiver 2014, the Winter semester
MW	More WeBWorK
LW	Less WeBWorK

INTRODUCTION

Many statistics instructors appreciate the adage "students learn statistics by practicing statistics". Exercises give students the opportunity to practice the statistical methods, which enhances their learning. But what is equally important is the feedback that students receive. Exercises that provide feedback have a large and positive effect on student learning, whereas homework that does not receive feedback has little effect. Feedback is also important for student motivation. Students who do not receive any feedback report experiencing the greatest frustration with homework, and are less likely to complete the exercises. In addition, it has been shown that immediate feedback is usually more effective than delayed feedback (Zerr, 2007; Burch & Kuo, 2010; Halcrow & Dunnigan, 2012). Since doing exercises is important to student learning, it would be beneficial to develop and assess a strategy that will encourage students to do more exercises while also providing immediate feedback and encouragement.

Traditional written exercises have two significant disadvantages. The first is that the feedback process is often very slow. A student may try several solutions on their own, but in the end they submit one response, and by the time it is corrected and feedback is given, the class has moved on. The second disadvantage is that written exercises can generate a large amount of correcting for the instructor. Online homework systems such as WeBWorK offer the student instant feedback while freeing instructors from the time-consuming task of grading the exercises, allowing instructors to use the time in more productive ways. WeBWorK is an open-source online homework system; although originally designed to provide problems for math and science students, WeBWorK programming allows for the creation of a variety of statistical methods questions which can be used in the Quantitative Methods course.

Through the use of a quasi-experiment, this research project measured and analysed the effects of using WeBWorK exercises on students' grades and the number

of exercises they attempted in the Quantitative Methods course in the Social Science program at Vanier College. In addition, a survey was used to elicit a qualitative description of students' perception of the exercises as well as greater information on their motivation to do the exercises.

In the first chapter of this study the pedagogical context is described and the topic is introduced. The problem is defined, along with the proposed solution and a statement of the purpose of this research. The second chapter describes the theoretical framework upon which the research is based. The third chapter examines and reviews the scholarly research along three themes: Online Exercises and Academic Performance, Motivation to do the Online Exercises, and Perceptions of Students Regarding the Online Exercises. Relevant concepts are operationally defined. This chapter concludes by stating the specific research questions that this study tries to shed some light upon. In the fourth chapter, the methods and procedures used to collect the data are described. The sample and target populations are identified and the instruments of data collection are explained. The fifth chapter presents an analysis of the data collected, and is divided into four sections. The first section presents descriptive statistics on the data, while the three remaining sections each address one of the specific research questions. The final chapter is a discussion of the findings. It also describes some of the limitations of the study. Finally, some of the new issues that arose from doing this project and suggestions for future research are described.

This research project has been a valuable learning experience. Although no significant results were found to support the hypothesis that simply doing WeBWorK exercises results in better test performance, the researcher has learned more about the design of a research project, and also identified areas for further research and study. The results will be shared with other QM teachers with the intention that more of them will adopt this useful teaching system.

CHAPTER ONE: STATEMENT OF THE PROBLEM

The Social Science program in CEGEP includes three methodology courses: Quantitative Methods, Research Methods, and Integrative Project. At Vanier, students take the Quantitative Methods (QM) course first, usually in their second semester. Because it is a required course, it is important that students ultimately pass this course.

Understanding statistical reasoning and applying statistical methods are the primary learning outcomes of this course. Having taught this course many times, and from informal discussion with other teachers, it is known that most QM instructors assign written exercises because they understand the premise that "practice makes perfect". However, the pedagogical value of traditional written homework exercises is compromised by the fact that any feedback is received well after the assignment is competed. Written homework handed in at the end of a class may not be returned until one or more class periods later. This often can completely erase the benefit, as the focus of the course has shifted by then. By the time the homework is returned, the class has moved on to other topics, and students are more focused on the current problems.

In course assessments, students often indicate that they appreciate frequent, detailed, and prompt feedback on their work. Homework that is graded or that receives feedback has a large and positive effect on student learning, whereas homework that does not receive feedback has little effect on student learning. Homework exercises also have the potential for improving the student's perception of his or her ability. Students who complete the exercises on a regular basis often report feeling more confident about the course. However, the homework needs to be structured in such a way that it is challenging enough not to be perceived as busy work and yet, given an appropriate amount of effort, still allows the student to achieve a level of success. The WeBWorK system as it was used in this project did give immediate feedback to students in the form of telling them whether the answer they entered was right or wrong.

However, if the answer was incorrect, the student was not given any futher guidance towards resolving the error.

Success is a powerful influence on the motivation to achieve. Students often perceive success as reinforcing and they will be more engaged if they expect to be successful. The option to retry incorrect problems is a positive instructional strategy since it conveys the message to students that it is okay to make mistakes when learning, and to keep trying. Many students in the Social Science program claim to have math anxiety, or at least a dislike of anything mathematical. This is why it is important to choose exercises that offer students the opportunity to demonstrate their understanding, or to try again without getting discouraged if they do not get the right answer the first time.

WeBWorK is an open-source online homework system. Although originally designed to provide problems and exercises for math students, WeBWorK has also been implemented in many other scientific and technical disciplines. The WeBWorK library already contains a number of statistical exercises, and these have been used or adapted to reflect the content and methods of the Quantitative Methods course as it is taught at Vanier College.

An important pedagogical benefit of the WeBWorK system is that it offers students instant feedback while a problem is still fresh in the student's mind. It instantly tells students if their answers are right or wrong , and allows them to rework the problem and correct their mistakes. This research project is an attempt to seek evidence as to whether this feature of the WeBWorK system will result in better academic performance on tests and the final exam.

CHAPTER 2: CONCEPTUAL FRAMEWORK

This research begins with the premise that active learning is an important factor in student success, particularly in the QM course. While most QM teachers would agree that completing exercises — an ingredient of active learning — is beneficial to student learning, in this chapter we will look at some of the theoretical premises that underlie this belief. In each case, we try to connect some of the important ideas in the field of Education Theory with the specific topics of this current research paper.

We will look first at general theories of learning in order to explain why exercises are used as an important component of most QM courses. Constructivist theories promote active learning and can help us to understand why doing exercises can be an important part of student learning. Theories of motivation can help us to understand why not just working on the exercises but also persevering until achieving success is such an important condition. While most teachers wish that their students were intrinsically motivated to do all the exercises, many students need extrinsic incentives and constant feedback in order to complete and therefore benefit from the assigned exercises.

1 CONSTRUCTIVISM

A theory of learning which has been widely accepted in education stems from the work of Jean Piaget, and has been labelled constructivism. This theory describes learning as actively constructing one's own knowledge (Garfield, 1995). According to Piaget, learners construct knowledge by performing actions and reflecting on the results (Larson, Young, & Leibham, 2011). Students learn better through practice; practice may mean hands-on activities, working in small groups, or using the computer (Garfield & Ben-Zvi, 2007). While the traditional method of teaching statistics is based on the premise that much of the learning comes from reading the textbook, attending lectures, and taking notes regularly, the constructivist framework posits that students

learn statistics only if they actually practice doing statistics (Basturk, 2005). When students do statistical exercises, they are practicing the methods themselves and are actively engaged in constructing their own knowledge and understanding of the procedures and the statistical ideas that are involved.

1.1.1 *Scaffolding*

Scaffolding is an important concept in the constructivist paradigm. The term is used as a metaphor for any kind of support or reinforcement that is given to students during the learning process. Like the physical scaffolding that is used in building construction, student learning is constructed based on meaningful activities designed to help the student climb to the desired educational goal (Callison, 2001). While doing exercises to practice the skills and methods of statistics, the feedback of the teacher is a form of scaffolding. In doing WeBWorK exercises, the system gives immediate feedback in the form of telling the student whether the answer they entered is correct or not. This is another form of scaffolding.

2 MOTIVATION THEORIES

2.1 Self-Determination Theory

According to self-determination theory, the incentive to learn is motivated by three needs: the need for competence, the need for relatedness, and the need for autonomy (Ryan & Deci, 2000). Completing a set of exercises offers students the potential to feel competent that they understand the material. Such success then makes them feel more connected to the course. Finally, completing the exercises on their own is an autonomous activity, and satisfies this need as well.

2.1.1 *Self-Regulation*

Self-regulation is a pedagogical concept that refers to the thoughts, affects, and behaviours used to attain learning goals. The main tenet of self-regulated learning theory is that students learn more effectively when they are responsible for their own learning (Schunk, 2001). Self-regulated learners enlist self-reactive influences to motivate their efforts and employ appropriate strategies to achieve success (Hong, Peng, & Rowell, 2009). Self-regulated learning theory (Pintrich, 2004) has four general assumptions about learning. The first is that learning is an active and cognitive process, the second is that learning is enhanced by a sense of control, third, that learning has a goal, and the fourth assumption is that that self-regulatory activities are mediators between personal characteristics and performance.

Self-regulation operates through various subsets of psychological functions that include motivational beliefs (perception that the exercises provide some value), motivational process and outcome (the desire to expend some effort doing the exercises), and metacognition (self-monitoring of the effectiveness of doing the exercises). Thus, self-regulated learners appraise tasks such as homework and direct and monitor their own behaviours by motivating their efforts, being persistent when they encounter difficulties, and utilizing appropriate cognitive and metacognitive strategies in order to complete the tasks successfully (Hong, Peng, & Rowell, 2009).

2.2 Attribution Theory

The attribution theory of achievement motivation is the theoretical orientation most widely used and best suited to explain academic performance in math or statistics classes (Locklear, 2012). Attribution theory attempts to explain how a person's perception of a past success or failure contributes to their future motivation and success. It incorporates behaviour modification theory by suggesting that students are motivated by successful outcomes that allow them to feel good about themselves. It also incorporates self-efficacy theory by emphasizing that a student's self-perception can

influence how they view the success or failure of their efforts. A student's belief about the cause and probability of their success and failure will greatly influence their level of academic achievement (Locklear, 2012). This is particularly important in the QM course, which is perceived by students as the most "mathematical" course they have to take as part of the Social Science program. Many students in this program have a real or imagined belief that they are "not good at math". The Quantitative Methods course looks so much like a mathematics course that it sometimes arouses this negative reaction.

3 STUDENT-CENTRED LEARNING

Constructivism, self-determination, and attribution theories are the foundation for the model of stu-centred learning (SCL). The SCL model suggests that students feel more empowered when they access and use their own sources of knowledge and actively pursue their own learning (Judi & Sahari, 2013). In the case of completing exercises, this is certainly an active and cognitive process. Doing the exercises reinforces for the student the sense that they have effectively learned the topic, and also provides a clear indicator that they are capable. This often encourages them to continue to do other exercises. Undertaking this self-regulating behaviour is then reflected in better academic performance.

4 THE IMPORTANCE OF HOMEWORK

Homework has been defined as "tasks assigned to students by school teachers that are meant to be carried out during non-school hours" (Zimmerman & Kitsantas, 2005, p. 398). The importance of homework to advanced cognitive development has been established. It is an activity related to motivation, mastery of material, and to achievement (Hauk & Segalla, 2005). Homework is related to achievement at two levels. A homework effect at the class level (or homework assignment effect) is found when students in classes with a higher quantity or quality of homework have better achievement gains than students in other classes with less homework. A homework

effect at the student level (or homework completion effect), is found when students in the same class who differ in their homework behaviour (for example, time spent on homework or number of homework assignments completed) show differential outcomes (Trautwein, 2007).

When students do homework exercises in a statistics course, there are many benefits. First, by actively practicing the methods and procedures themselves, they become much more proficient. This is consistent with the constructivist theory of learning. According to attribution theory, when students achieve success while doing the statistics exercises, this enhances their sense of control. This not only helps alleviate any statistics anxiety they may have, it also serves as a motivating factor, and encourages the students to continue doing the exercises. Undertaking this self-regulating behaviour is then reflected in better academic performance (Mills, 2003).

Unfortunately, the value of traditional written exercises is compromised by the fact that any feedback is received well after the assignment is competed. A proposed solution that preserves the pedagogical benefits of actively engaging the students in exercises that enhance their learning yet provides instant feedback and the possibility of immediately reattempting the problem is to use WeBWorK exercises in the Quantitative Methods course.

5 FEEDBACK

The effectiveness of homework exercises is partly due to the attempt-feedback-reattempt cycle (Zerr, 2007). Feedback is important since it allows the instructor to guide students through to a correct solution. However, the pedagogical value of traditional homework assignments is compromised by the fact that any feedback is received well after the assignment is competed. By this time, the student is far less motivated to reattempt the problem (Butler & Zerr, 2005).

Research on adults' memories of learning mathematics during their school days suggests that a sequence of events is triggered when students experience an initial

failure to understand. Initial confusion is followed by a failure to receive adequate explanations or assistance from the teacher, leading to a loss of confidence and panic over the sense of lack of control of one's own comprehension (Mvududu, 2005). Perhaps this helps explain why some Social Science students identify the statistics courses as the most anxiety-inducing course in their curriculum. Statistics anxiety can be described as "the apprehension that occurs when an individual is exposed to statistical content, problems, instructional situations, or evaluative contexts" (Macher, Paechter, Papousek, & Ruggeri, 2011, p. 2). However, this anxiety may be tempered if students are given the opportunity to experience success.

An online homework system that provides instant feedback and which also allows immediate repeated attempts means that students who may have convinced themselves that they cannot do statistics now have the opportunity to try until they get it right. They can experience success in statistics and improve their self-efficacy. When students are able to attempt a problem multiple times, many will repeat the problem until they get it correct. This not only allows more practice, it also develops persistence. Zerr (2007) found that students credited the feedback from multiple attempts at homework problems for their understanding and exam performance. This cycle of feedback/multiple attempts also enhances motivation because it allows for a high degree of success when sufficient effort is put forth by students (Halcrow & Dunnigan, 2012).

When the WeBWorK system offers immediate positive feedback (the student is told that their answer is correct), this is likely to be reassuring and motivating. However, if the student is told that their answer in not correct, we might assume that this will be discouraging and may actually reinforce any existing math anxiety. However, unlike with traditional written exercises, this initial distress may be tempered by the ability to immediately re-try the problem. In this current study, we focused on the immediate feedback function of the WeBWorK system versus the delayed feedback of the written exercises to determine whether that would have a significant impact on student grades.

CHAPTER 3: LITERATURE REVIEW

Having examined some of the theories that throw light on the topic of this paper, we will now examine in some detail the empirical research that has been done on this issue. Predictably, most of the studies used samples of American undergraduate students. While there are important qualitative differences, these students may be considered roughly comparable to Cégep students. Some of the reports cited have studied the effectiveness of online homework exercises in general, and not specifically the use of the WeBWorK platform. This is still compatible with the theoretical premise that active online learning with instant feedback and the possibility of reattempting the problem is better than traditional written exercises with delayed feedback. Finally, while some studies have looked specifically at the benefits of doing exercises to learn statistics, it is also helpful to consider research projects that used students in other disciplines such as accounting, calculus, or chemistry.

Three important themes have emerged from this review: Online Exercises and Academic Performance, Motivation to do the Online Exercises, and Perceptions of Students Regarding the Online Exercises. These will be discussed in detail in the following paragraphs.

1 ONLINE EXERCISES AND ACADEMIC PERFORMANCE

This first theme reflects the impact of online exercises on academic performance. Many of the schools that have implemented systems for online exercises have studied their effectiveness, and these have repeatedly and consistently been shown to improve student learning (usually operationalized as test scores or final grades). While some studies measured the impact of doing online exercises versus not doing them, other studies compared the relative effectiveness of online exercises compared to written exercises.

Some research projects have measured whether doing online exercises results in better performance than not doing the exercises. Zerr (2007) used an online homework system developed at the University of North Dakota in a first-semester calculus class of 27 students. The students were assigned 2 or 3 homework sets per week. If the first attempt at a problem was unsuccessful, the student was given immediate feedback and presented with another different but similar problem. Students had an unlimited number of attempts, so by repeatedly trying, a perfect score was quite possible. The students were divided into two groups – those who got fewer than 17/26 perfect scores on the homework assignments, and those who got more than 17/26 perfect scores. The average exam score for students in the first group was 69.61 percent and the average exam score in the second group was 84.43 percent; the difference in means was significant at 99 percent. Pre-test scores showed that there was no previous significant difference between the two groups (Zerr, 2007). This demonstrates that students who did the online exercises, and who performed well on the exercises, achieved significantly higher exam scores.

In another study, all of the 121 students from an introductory course for statistics in Dentistry at the University of Barcelona were randomly assigned to use e-status, a web-based tool able to generate different statistical exercises and to provide immediate feedback to students' answers. The researchers found that the effect of using e-status on the student grade was an improvement of 0.48 points on a ten-point scale, which was statistically significant ($p = 0.014$). Each student was given the choice whether to use the e-status tool; the researchers decided against assigning one group to use e-status while the other did not because they wanted to avoid the ethical implications of having one group deprived of a beneficial resource (González, Jover, Cobo, & Muñoz, 2010). In the current research project design, we addressed this ethical issue by using a staggered treatment schedule throughout the semester.

As a further refinement of the correlation between doing online exercises and grades, some researchers have looked not only at whether students did the homework or not (homework completion) but also considered how well the students did the

homework (homework scores). A six-year study collected data from 13 sections of the same introductory chemistry course, with 3,806 students and 5 different instructors. The correlations between homework scores and grades on the final exam were always positive and ranged from a low of 0.33 to a high of 0.65. The mean of the normalized homework score for each class was used as the cut-off to divide each class into two groups—a high homework scorers (HHS) group and a low homework scorers (LHS) group; in every instance, the HHS group outperformed their counterparts in the LHS group and the differences were statistically significant ($p \leq .05$) with the exception of one class (Arasasingham, Martorell, & McIntire, 2011).

While the above studies demonstrate that doing online homework has positive outcomes on academic performance, we might also ask whether online exercises are more effective when compared to traditional written exercises. Two teachers at the University of North Dakota each taught two sections of Calculus I; each had an experimental group of students who used online homework and a control group who did not. One teacher reported that the experimental group always scored higher than the control group, and three out of the five exams indicated significant improvement for the experimental group. The second teacher found higher average scores for the control group on three of the exams, but none of the differences between the two groups were significant (Halcrow & Dunnigan, 2012).

Another comparison of traditional paper assignments and online homework assignments was done for multiple sections of College Algebra at the University of Pennsylvania. The three sections that did pencil-and-paper homework assignments had a total of 65 students; the two sections that did the online homework had 61 students. The researchers found that students who used the online system performed significantly better on three term exams, although the difference between the two groups was not significantly higher on the final exam (Burch & Kuo, 2010).

A larger study involved 1175 students in calculus at Rutgers University. The control group of 368 students were not given WeBWorK exercises, while the

experimental group of 807 students were given the WeBWorK exercises. Both groups also did written homework but in the WeBWorK group, 11 of the written problems per week were replaced with WeBWorK problems. The students in the WeBWorK group showed a small but statistically significant improvement of 4 percent on the final exam, even after adjusting for placement scores. The researchers also reported that the effectiveness of the WeBWorK depended dramatically on the number of problems attempted. There was a two letter grade difference (D to B) on the final exam between those who did most of the WeBWorK problems and those who didn't (Hirsch & Weibel, 2003). This supports the findings of Zerr (2007), which found that having access to the online exercises was not sufficient to increase test results; students also had to do the exercises in order to reap the full benefits.

It seems there is a positive correlation between doing online exercises and academic performance (higher grades). Some of the studies reviewed found that students who did the online exercise outperformed their peers who did traditional written exercises. It was also observed that students who did more online exercises scored higher on tests and exams than students who completed fewer of the exercises. So it seems that there are benefits to completing all the online exercises. Yet, we know that students differ in the number of exercises they complete. The second theme that we will examine is what motivates students to actually do the online exercises.

2 MOTIVATION TO DO THE ONLINE EXERCISES

Task value is students' motivational beliefs that the task (e.g., homework) is important and useful (utility value) or interesting and enjoyable (intrinsic value). Tasks that are intrinsically valued have shown positive relationships to achievement. Likewise, students' utility values of homework and grades are positively related (Hong, Peng, & Rowell, 2009).

One factor that increases the utility value of a homework exercise is the grade attached to it. One study found that more students attempted the WeBWorK exercises

because they knew that that every problem was graded and recorded (Roth, Ivanchenko, & Record, 2008). Since WeBWorK allows for multiple attempts, some students may be more inclined to re-attempt problems if they don't get the correct answer the first time. One research study allowed students to re-attempt a problem three times, and that the highest score would count. The authors of this study found that 65 percent of the grades earned were higher than 90 percent (Butler & Zerr, 2005). This skewed distribution suggests that students were quite willing to re-attempt problems as often as they could in order to get them right. The possibility of re-attempting exercises also increases the likelihood of success, which is a reinforcing motivational factor (Zerr, 2007).

In an attitudinal survey, many Chemistry students gave the online homework system credit for helping them to learn and better understand the material. (Arasasingham, Martorell, & McIntire, 2011). Another study, also involving Chemistry students, found a significant improvement in success rates following the implementation of an online homework system. The study also asked students to complete a self-report survey on their experience with the homework system. The majority of students reported that they viewed the assignments as worth the effort (83.5 percent), relevant (90.5 percent), challenging (83.4 percent), and thought- provoking (79.0 percent). Most also recommended that the online homework should continue to be used (Richards-Babb, Drelick, Henry, & Robertson-Honecker, 2011).

The intrinsic value of a learning task considers whether the task is interesting and enjoyable. Students using an online homework system in an Algebra class expressed their appreciation of the immediate feedback provided by the system (Burch & Kuo, 2010). The immediate feedback factor has been reported by several other studies (Zerr, 2007; Roth, Ivanchenko, & Record, 2008; Garfield & Ben-Zvi, 2007). This is consistent with the theoretical model of learning which posits an attempt-feedback-reattempt cycle. Also consistent with this model is the possibility, with online exercises, of multiple attempts at the same problem. This is different from written exercises, in which students can work on a problem as much or as little as they wish,

but can usually only submit one solution for correction and grading. While no one enjoys getting a wrong answer, this is less discouraging if one gets immediate feedback, and right away has the opportunity to try again.

All of the studies cited in this review have been carried out since 2000; the earliest research project (Hirsch & Weibel, 2003) collected data in 2001. None of the studies in this review have reported either lack of access to the online system or lack of computer skills as factors which reduced the effectiveness of the online exercises. This reinforces the premise that the current generation of students are digital natives. They grew up surrounded by and using computers, videogames, digital music players, cell phones, and all the other toys and tools of the digital age (Prensky, 2001).

Since most of the current students are digital natives, statistics anxiety may be reduced by using computers, which for most students are a familiar and everyday technology, to teach statistics (Van Gundy, Morton, Liu & Kline, 2006). In several self-report surveys, a large number of students reported that they preferred the online homework because they could do it whenever they wanted (Burch & Kuo, 2010; González, Jover, Cobo, & Muñoz, 2010). In principle, written exercises could also be done at any time, and anywhere, so it is interesting that students identified the anytime, anywhere factor as an advantage of the online exercises only.

3 PERCEPTIONS OF STUDENTS REGARDING ONLINE EXERCISES

As teachers, we often try to choose instructional strategies that will be effective and enjoyable for our students. But it is important that from time-to-time, we check in with the students to find out what their perception of a particular strategy or teaching method really is. Many of the studies cited in this review used a quasi-experimental research design to measure the quantitative effect of using online homework on student achievement (grades). Many of the studies also included a qualitative analysis, based on student surveys, of students' perceptions of the online systems. In this section, we will summarize these findings.

3.1 The Effectiveness of Online Exercises

Most students understand, at least on a cognitive level, that success in school requires some effort. Doing homework is one example of a task that probably contributes to academic success. In interviews of first-semester Calculus students at the University of North Dakota, students understood that the online homework probably contributed to their success in the course (if they did the homework and succeeded). What students liked the most about the online exercises was that the system was easy to use (user-friendly software), that they were allowed multiple attempts on the problems, and that they were given immediate feedback in the form of correct solutions to incorrectly done problems (Halcrow & Dunnigan, 2012).

In general, students regard online homework in a positive light and see the online exercises as a useful addition to the course. Nearly all of Butler and Zerr's (2007) Calculus students strongly agreed that "the online homework provided a worthwhile addition to the course". It would be naïve to think that online exercises work for all students. While most of Richards-Babb et al (2011) Chemistry students recommended that the online homework should continue to be used, 13.1 percent said that they would be would be less likely to take another course with online homework, 13.1 percent agreed that online homework was a waste of time, and 16.1 percent agreed that online homework did not further their understanding of chemistry concepts. Nevertheless, it seems that online exercises are positively perceived by most students.

3.2 Using Computers

Computers have a mediating effect on learning. At a very fundamental level, student perceptions of the effectiveness of online exercises will be influenced by their pre-existing knowledge of computers, comfort in using them, and ease of access to the software (Hauk & Segalla, 2005). Even computer-savvy students may become frustrated with a system if they experience difficulty using it. Coping with issues such

as syntax or entry errors increases student frustration, and may create unintentional obstacles to learning (Roth, Ivanchenko, & Record, 2008).

4 GOAL OF THE CURRENT STUDY

The goal of this particular research project is to determine whether the positive results found in other disciplines are generalizable to teaching and learning Quantitative Methods. This study addresses a gap in the existing literature by examining the outcomes of learning QM using either WeBWorK or written exercises.

5 RESEARCH QUESTIONS

This research project measured and analyzed the effects of using WeBWorK exercises on students' academic performance in two Quantitative Methods classes at Vanier College. It also explored students' perceptions of the WeBWorK and written exercises.

5.1 General Research Question

How do WeBWorK exercises affect the student learning process and outcomes in the Quantitative Methods course in the Social Science program?

5.1.1 *Specific Research Question 1*

Will students who do WeBWorK exercises get significantly higher grades than students who do written exercises?

5.1.2 *Specific Research Question 2*

Will students who complete more of the WeBWorK exercises get significantly higher grades than students who complete fewer of the WeBWorK exercises?

5.1.3 *Specific Research Question 3*

What are students' perceptions/opinions regarding the WeBWorK and written exercises?

CHAPTER 4: METHODOLOGY

1 RESEARCH DESIGN

Through the use of a quasi-experiment, this project measured and analysed the effects of using WeBWorK exercises in the Quantitative Methods course at Vanier College. Two sections of QM were used, which allowed for independent sample comparison between the two sections and a matched-pairs comparison within each section.

1.1 Population and Sample

The population of interest was all students registered in the Quantitative Methods (QM) course at Vanier College in the semester that the data was collected (Autumn 2014).

A convenience sample of two sections of the QM course taught by the researcher was used. Enrollment was 32 students in Group A and 36 students in Group B; after omitting students who dropped the course, as well as students who did not sign the consent form, the final total sample size was 58 students (27 in Group A and 31 in Group B).

Because of the registration procedures at Vanier, random assignment of students to the two sections was not possible. However, given that there are several sections of QM offered, and that students are assigned to sections via a computer program, one could assume that the convenience sample is quite representative of the population of Social Science students at Vanier College.

Although not central to the research questions, certain demographic information was elicited from the students which allowed for a comparison of the two groups along certain variables such as gender and semester of study. The two groups were

comparable along both these dimensions. A pre-test of math skills was given during the first class to both groups. This introduced the students to the WeBWorK platform, and also served as a measure of math skill levels for each group. The difference between the two groups was not statistically different.

1.2 Method

A quasi-experimental method was used with a matched-pairs design. The matched-pairs were the students within each section (each matched pair being the same student at different times and under different conditions). Pre-testing was therefore not necessary in order to match the pairs. Their performance was measured with and without the treatment (the WeBWorK exercises). A comparison was also made between the two sections using the independent sample method.

In order to control for variation in the difficulty of the course content across the semester, a crossover design schedule was used (See Table 1). WeBWorK exercises were given to Group A for the first third of the semester, not for the second third, and then re-introduced for the final third. In Group B, WeBWorK exercises were not used in the first third, but were introduced for the second and final parts of the course. Academic performance (measured by graded assessments) under both conditions was compared within and between the two sections. See Appendix D (Table 13) for a more detailed table of the topics covered.

Table 1 - Crossover Design Schedule

	Module 1	Module 2	Module 3
Group A	WeBWorK	Written	WeBWorK and Written
Group B	Written	WeBWorK	WeBWorK and Written
Evaluation	Test 1	Test 2	Test 3
Context	Same content Same instructional methods Different exercises	Same content Same instructional methods Different exercises	Same content Same instructional methods Same exercises
Analysis	Comparison between groups (type of exercise) Comparison within groups (exercise completion)	Comparison between groups (type of exercise) Comparison within groups (exercise completion)	Comparison within groups (exercise completion)

The WeBWorK exercises were written by the researcher. These were pilot-tested for clarity and functionality in the A13 and H14 semesters with students in two sections of the QM course. The WeBWorK system automatically and immediately told students whether the answer they entered was right or wrong. No further feedback was given by the WeBWorK system (See Appendix E, Figures 4, 5, and 6 for examples of the WeBWorK interface).

The written exercises were a combination of those found in the textbook and those written by the researcher. These were corrected and returned to the student by the following class period. A check mark was used to indicate a correct response. In the case of an incorrect response, the instructor usually wrote some kind of feedback. For example, in the hypothesis test exercises, a student might incorrectly use the formula for a mean rather than for a proportion. The feedback would be in the form of a question "Is this a mean or a proportion?" written on the paper.

Students were also asked Likert-type questions to report their perceptions about which type of instructional tool they enjoyed the most and found most valuable. In

addition, the questionnaire asked students to estimate the time they had spent studying for each of the two types of exercises, as a measure of task engagement.

Both sections were taught by the same instructor (the researcher). The same textbook was used, the same content was covered, and students in both sections had the same lectures, in-class exercises, written assignments, and tests. At Vanier, all QM students write a common and comprehensive final exam at the end of the semester.

1.3 Ethical Considerations

The research project was approved by the Research Ethics Board at Vanier College in May, 2014 (See Appendix A). Standard consent forms (see Appendix B) were used to obtain written acceptance to participate in this study. Those students who did not wish to participate took part in the course work with the other students, but the data they generated was not used in the study. The student surveys were distributed to each section during a class near the end of the semester, and took 15-20 minutes to explain and to administer. The survey was sent out electronically to students who were absent, and in the end, there were 40 students who completed the survey. There was no risk or harm to any of the participants, and the confidentiality of all responses was safe-guarded. Another teacher went to both sections during the first week of the semester to explain the research project and to hand out and collect the consent forms. This teacher also handed out and collected the surveys at the end of the semester. Both the consent forms and the surveys were kept by this teacher until the following semester and after the final grades for the course were submitted to Vanier College. Only then were these given to the researcher. This was done to protect the confidentiality of the respondents and to ensure that the researcher would not know during the semester who had consented to participate and who had completed the survey. The data (surveys, grades, exercises completed) will be kept by the researcher for two years. The WeBWorK system stores student data automatically; this will be deleted by the researcher after two years.

2 INSTRUMENTS

2.1 Tests and the Final Exam

Instrument: There were three in-class tests and a final exam; each of these had equal weighting (20 percent). The remaining 20 percent of the final grade was for completing the exercises, both written and WeBWorK combined. Because exercise completion contributed to the students' final grade, only the scores on the tests and final exams were used to measure the correlations between exercise completion and grades. The three tests were written by the researcher while the final exam was collectively written by a group of QM instructors.

2.2 Doing the WeBWorK Exercises (WeBWorK Exercise Completion)

Instrument: WeBWorK allows instructors to observe student activity for each exercise. The instructor can see which questions in a problem set a student attempted, how many times they attempted each question, and also whether or not they got the correct answer (See Appendix E, Figure 7). Since exercise completion may be coded as a binomial variable, criteria were set to define what was considered a completed exercise. An exercise set in which a student scored at least 60 percent (regardless of the number of attempts) was considered a completed exercise. Exercise sets had 10 to 12 individual problems. Group A were assigned seven WeBWorK exercise sets while Group B were assigned eight WeBWorK exercise sets.

2.3 Doing the Written Exercises (Written Exercise Completion)

Instrument: During the semester, written (pencil-and-paper) exercises were assigned. Some of these were created by the instructor, and some were from the textbook. The completion of these exercises may be coded as a binomial variable. An exercise in which a student scored at least 60 percent was considered a completed exercise. Each exercise contained four to ten individual problems. Group A were assigned eight written exercises while Group B were assigned seven written exercises.

2.4 Survey on Students' Perceptions/Opinions of the WeBWorK Exercises

Instrument: The student survey (see Appendix C) was used to collect data about students' perceptions and opinions of both the WeBWorK and written exercises. The survey was put together by the researcher, and is a compilation of questions typically used in self-reporting pedagogical questionnaires. Twenty-two Likert-scale questions asked students to rate various aspects of the two types of exercises on a 5-point scale, 1 being the lowest and 5 being the highest rating. A paper copy of the questionnaire was distributed to all the students in both groups during the last week of classes. The survey was sent by MIO (an email system internal to Vanier) to any student who was absent from class when the surveys were distributed. Only the survey results of those who had signed a consent form were used.

CHAPTER 5: PRESENTATION AND ANALYSIS OF THE DATA

This chapter is divided into four sections. The first section presents descriptive statistics on the data. The remaining three sections each address one of the specific research questions. The second section examines whether students who complete more of the WeBWorK exercises get significantly higher grades than students who complete fewer of the WeBWorK exercises. The third section addresses the question of whether students who do WeBWorK exercises get significantly higher grades than students who do written exercises. The last section is based on the data collected through the student survey and focuses on students' perceptions and opinions of the WeBWorK and written exercises along various dimensions.

1 DESCRIPTIVE STATISTICS

This first section presents descriptive statistics about the performance of each group along various measures — the math pre-test, grades on the tests and exam, and performance on the WeBWorK and written exercises.

1.1 Math Skills Pre-Test

During the first week of class, a math skills pre-test was given to both groups to see if there was any significant difference in mathematical ability between the two sections. The test consisted of ten questions and was done on WeBWorK. The results for each group are presented in Table 2:

Table 2 - Math Skills Pre-test Results

	Group A (n=27)	Group B (n=31)
Mean	8.41	8.19
Median	9	9
Standard Deviation	1.34	1.27

An independent means t-test (2-tailed) showed that there was no significant difference between the groups, where $t(56) = 0.62$, $p = 0.5361$. We can assume that both groups were equivalent in terms of basic math skills.

1.2 Grades

The QM course was divided into three units. After each unit, there was a test based on the material that was covered in that unit. There was also a comprehensive and common final exam which was given to all QM students in all sections during the final exam period. Each of the three tests and the final exam had equal weighting (20 percent each). All the tests and the exam were graded by the researcher. Table 3 shows the mean grades for each unit test and the final exam, for each group.

Table 3 - Grades for Tests and Final Exam, by Group

	Group A				
	Test 1	Test 2	Test 3	Final Exam	Total (Tests + Exam)
Mean	82.70	73.06	85.70	73.93	78.85
Median	85.00	73.75	90.67	74.00	79.17
Standard deviation	11.50	15.98	11.27	12.06	9.74
	Group B				
	Test 1	Test 2	Test 3	Final Exam	Total (Tests + Exam)
Mean	84.85	74.03	87.70	75.59	80.54
Median	86.00	75.00	90.67	81.00	82.79
Standard deviation	9.89	15.07	8.89	15.14	10.28

The distribution of grades for each assessment were typically and predictably normal around a centre of about 80 for the tests and 75 for the final exam. The distributions of grades on tests and the final exam combined, and for each group, are shown in the boxplots below. The distribution of Group A is symmetric while the distribution of Group B is skewed, due to a few low scorers and an outlier.

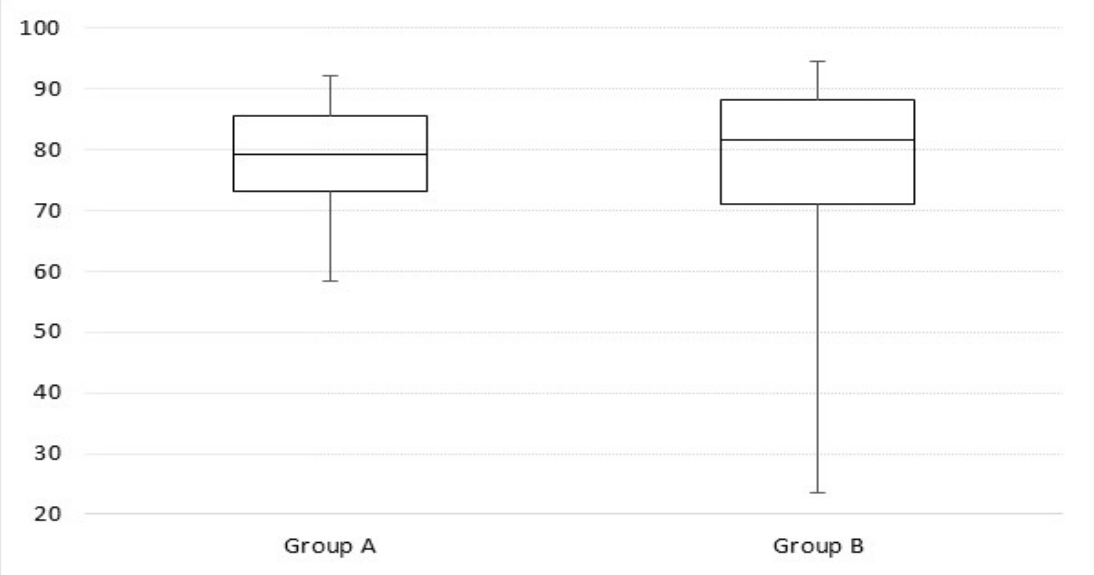

Figure 1 Boxplots of Grades, by Group

1.3 Exercises

Throughout the semester, students in each group were assigned 14 exercises. Students in Group A were assigned six WeBWorK exercise sets and eight written exercise sets, while students in Group B were assigned seven WeBWorK exercise sets and seven written exercises.

An exercise was considered completed if the student had a score of at least 60 percent. Table 4 summarizes how each group performed in completing the exercises.

Table 4 - Number of Exercises Completed, by Group and Exercise Type

	Group A		Group B	
	WeBWorK (out of 6)	Written (out of 8)	WeBWorK (out of 7)	Written (out of 7)
Mean	4.52	5.07	5.32	4.61
Median	5.00	5.00	6.00	5.00
Standard deviation	1.53	2.64	1.64	2.25
Percentage completed	75.33	63.38	76.00	65.85

Since each group was assigned different numbers of exercises, we can look at the percentage completion rates to compare them. On the WeBWorK exercises, Group A completed an average of 75.33 percent while Group B completed 76.00 percent. The difference in means is not significant. On the written exercises, Group A completed an average of 63.38 percent while Group B completed 65.85 percent. Again, the difference in means is not significant. However, it is interesting to observe that completion rates of the WeBWorK exercises were significantly higher than completion rates of the written exercises $t(114) = 6.979$, $p < 0.01$.

In both groups, and for both types of exercises, the largest category was that in which the student completed all the exercises. All students in both groups completed at least one WeBWorK exercise set. From the student surveys, we can compare the self-reported time required to complete each type of exercise. Among the 40 students who completed the survey, the average time taken to complete the written exercises was 42.8 minutes, which was significantly more than the average time taken to complete the WeBWorK exercises (34.3 minutes).

2 WEBWORK VS WRITTEN EXERCISES

Most theoretical models of how students learn would suggest that the use of active learning methods is often more beneficial for creating deeper and longer-lasting knowledge and understanding. Completing exercises is an example of an active learning strategy because the student applies his or her knowledge and skills while

working on the exercises. Yet, an important part of this process is the feedback that the student receives. It is essential that the student know whether or not they have answered correctly in order to confirm their understanding. It follows that the more quickly this feedback is given, the more useful it is for the student. Consistent with the active learning model, it is not just doing the exercises that helps students learn, it is the opportunity to make mistakes and to try again. Online exercises have an advantage over written exercises (that are only corrected and returned at a later date) since they can offer immediate feedback to the student. This also allows students to immediately try the problem again. It is this cycle of attempt, feedback, and re-attempt that is so conducive to learning.

We reviewed a number of studies that compared the academic outcomes of students who did online exercises, such as WeBWorK, to the outcomes of students who did the traditional written exercises. In many cases, significant differences were found. Students who did the online exercises often scored higher on tests and exams than students who did the written exercises. The present study tried to replicate these findings with two groups of Quantitative Methods students at Vanier College.

Our first research question was:

Will students who do WeBWorK exercises get significantly higher grades than students who do written exercises?

To answer this first research question, a crossover design was used in order to compare whether a group that did WeBWorK problems during one unit would score significantly higher on that unit test than the other group that did the written problems. This is a measure of the homework assignment effect.

Table 5 - Mean Grades on Unit Tests, in Percent, by Group

	Test 1	**Test 2**	**Test 3**
Group A	82.7	73.06	85.7
Group B	84.85	74.03	87.7

Independent sample t-tests were conducted for the results of each test, for the final exam, and for the total of tests and the exam. In no case was there a significant difference in mean grades between the two groups. See Appendix D for the detailed results. This suggests that grades on each test or on the exam were not significantly affected by whether the group did the written, WeBWorK, or both kinds of exercises.

When looking at total group scores, interpretation may be skewed by the fact that some students do not do all or any of the exercises. If we want to see whether students who do the WeBWorK exercises score higher than students who do the written exercises, we can compare two sub-groups. For each unit test, we selected only those students in each group who completed all the assigned exercises (whether written or WeBWorK) for that unit, and then performed an independent sample t-test to compare their unit test scores. Only the first two tests were compared; in the crossover design, students in both groups did both types of exercises in unit 3. The results are shown in Appendix D.

Even among the sub-group of students who completed all the exercises in each unit, there was no statistically significant difference in test scores based on doing either the written or the WeBWorK exercises. Furthermore, it was observed that in the first unit, 15 students in Group A (n = 27) completed all the WeBWorK exercises while only 11 students in Group B (n = 31) completed all the written exercises. In unit 2, only nine students in Group A completed all the written exercises while 11 students in Group B completed all the WeBWorK exercises. Predictably, in many cases it was the same students who did all the exercises in both units.

3 WEBWORK EXERCISES AND GRADES

In the previous section, we found that in this sample, there was no statistically significant difference in grades between students who did the WeBWorK exercises and students who did the written exercises. The theories of active learning would predict that students who do more WeBWorK exercises will perform better than those who do

fewer WeBWorK exercises. This is the homework completion effect. So, we now turn to our second research question:

Will students who complete more of the WeBWorK exercises get significantly higher grades than students who complete fewer of the WeBWorK exercises?

Because exercise completion contributed to the students' final grade and would be a confounding factor, only the scores on the tests and final exams (not the final grade) were used to measure the correlations between exercise completion and grades. Scatterplots show that there is a positive correlation between the number of exercises done and grades. This is true for both groups.

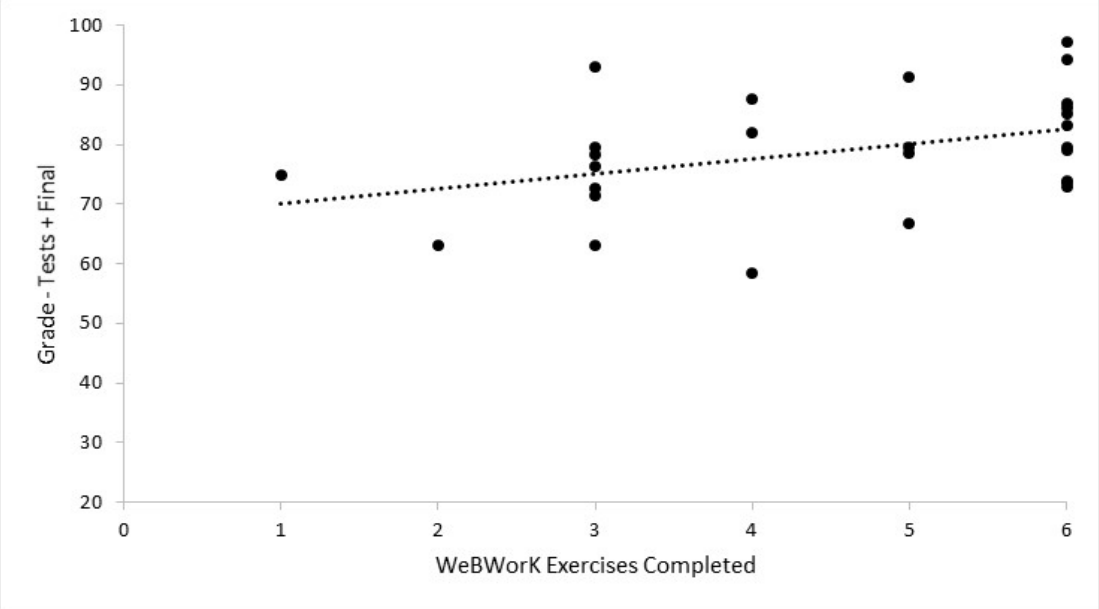

Figure 2 Scatterplot of WeBWorK Exercises Completed and Grades, Group A

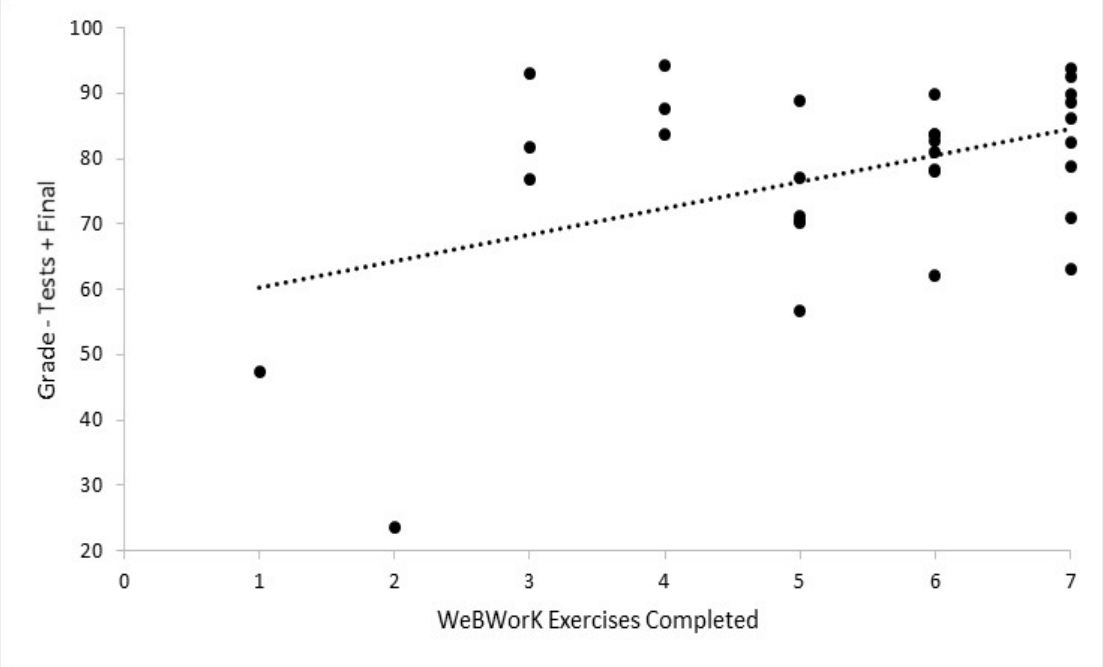

Figure 3 Scatterplot of WeBWorK Exercises Completed and Grades, Group B

In Group B, we see one outlier. This is a student who did not complete the course, but did not formally withdraw, and so received a very low final grade as well as only completing two of the WeBWorK exercises.

Correlations were calculated to measure the direction and strength of the straight-line relationship between the number of WeBWorK exercises completed and grades. Table 6 summarizes these correlations.

Table 6 - Correlations Between WeBWorK Exercises and Grades

Group	Correlation Coefficient
Group A, Test 1	0.62
Group B, Test 2	0.19
Group A, Test 3	-0.07
Group B, Test 3	0.83
Group A, Tests + Final	0.39
Group B, Tests + Final	0.44

These correlation coefficients show no real pattern. On Test 3, the correlation was very weak and slightly negative (-0.07) for group A, while for Group B, it was strong and positive (0.83). The explanation for this unusual result is that in Group A, most of the students completed all three WeBWorK exercises (which would result in a weak correlation, since there was variation in the grades but little variation in the exercise completion) except for four students who did not complete any of the WeBWorK exercises yet got high grades (which explains the slightly negative correlation). In Group B, the scores of two students created a strong positive correlation because they were extremely low in both grade and WeBWorK exercises completed; if these two scores are removed, the correlation drops to 0.11. The remaining correlations were generally weak to moderate, and positive. It appears that overall, doing more WeBWorK exercises is positively correlated with higher grades.

For comparison, we also calculated correlation coefficients between the number of written exercises completed and grades. These are shown in Table 7:

Table 7 - Correlations Between Written Exercises and Grades

Group	Correlation Coefficient
Group B, Test 1	0.37
Group A, Test 2	0.34
Group A, Test 3	0.30
Group B, Test 3	0.42
Group A, Tests + Final	0.28
Group B, Tests + Final	0.47

All of these correlations are positive but weak to moderate in strength. It appears that doing more of the written exercises is also positively correlated with higher grades, and this pattern is more consistent than that observed with the WeBWorK exercises.

For the first test, students in Group A did three WeBWorK problem sets for that unit. We divided the students in Group A into two sub-groups: those who completed 2

or 3 of the WeBWorK exercise sets (MW), and those who completed fewer than 2 exercise sets (LW). We also divided grades into two categories: high grade (more than the median) and low grade (less than the median). The observed data are shown in Table 8 below.

Table 8 - WeBWorK Completed in relation to Grades, Group A, Test 1

	High Grade > Median	Low Grade < Median
MW	12	6
LW	2	7

For Group A, Test 1, there is an association between the two variables. A chi square test of association between the two variables produces a chi-square statistic of 4.75, statistically significant at $\alpha = 0.05$.

For the second test, students in Group B did four WeBWorK problem sets for that unit. We divided the students in Group B into two sub-groups: those who completed 3 or 4 of the WeBWorK exercise sets, and those who completed fewer than 3 exercise sets. We again divided grades into two categories: high grade (more than the median) and low grade (less than the median). The observed data are shown in Table 9 below. Hardly any association can be detected between the two variables with Group B Test 2. The Chi square test shows no statistical significance.

Table 9 - WeBWorK Completed in relation to Grades, Group B, Test 2

	High Grade > Median	Low Grade < Median
MW	9	9
LW	5	8

4 STUDENT PERCEPTIONS/OPINIONS OF THE EXERCISES

This final section will describe and analyze the students' responses on the survey, which addresses the third research question:

What are students' perceptions/opinions regarding the WeBWorK and written exercises?

The student survey (see Appendix C) included 22 Likert-scale questions that tapped into various aspects of students' perceptions and opinions of both the WeBWorK and the written exercises.

Students were asked how much effort they put into doing each type of exercise. There was no difference in the reported effort put into completing each type of exercise (mean and median = 3 for both types).

When asked how much they felt doing a particular type of exercise helped them to learn the course material, the written exercises scored higher (mean = 3.9; median = 4) than the WeBWorK exercises (mean = 3.5, median = 3.5).

Students were asked to rate each type of exercise along six dimensions: clear, helpful, enjoyable, difficult, boring, and not helpful. A composite score was calculated; the first three categories were scored positively while the last three were scored negatively. For example, this is how the responses of these two students were scored:

Table 10 - Example of Scoring Student Ratings of Exercises

	Clear	Helpful	Enjoyable	Difficult	Boring	Not Helpful	Total Score
Student A	3	4	2	-2	-2	-3	2
Student B	4	4	4	-3	-3	-1	5

The mean score for the WeBWorK exercises was 3.4 and the mean score for the written exercises was 5.5. Overall, students gave a higher score to the written exercises. The written exercises also scored better than the WeBWorK exercises within

each of the dimensions. The difference in scores was statistically significant on the Helpful question ($t(39) = -2.84$, $p = 0.007$) as well as on the Not Helpful question ($t(39) = -3.23$, $p = 0.0025$). This suggests that students found the written exercises significantly more helpful than the WeBWorK exercises. Table 11 summarizes the student ratings of both types of exercise on each dimension.

Table 11 - Students Ratings of Exercises, by Type

	WeBWorK Exercises						
	Clear	Helpful	Enjoyable	Difficult	Boring	Not Helpful	Total Score
Mean	3.7	3.4	3.1	-2.0	-2.8	-2.0	3.4
Median	4	4	3	-2	-3	-2	4
	Written Exercises						
	Clear	Helpful	Enjoyable	Difficult	Boring	Not Helpful	Total Score
Mean	4.0	4.2	3.2	-1.8	-2.7	-1.4	5.5
Median	4	4	3	-2	-2.5	-1	5.5

When presented with the choice of having only written or only WeBWorK exercises, the mean score for only WeBWorK (3.1) was slightly higher than the score for only written (2.85). However, overall, students reported that they found the written exercises were better for understanding the basic statistical concepts and for learning the basic statistical methods. Unfortunately, we did not ask students to explain why they found one type of exercise better than the other. This may be a topic for further research.

Finally, students were asked to rate the WeBWorK and written exercises in terms of their perceived effectiveness in understanding the concepts and methods taught in the course. Once again, students found the written exercises to be more effective for learning the concepts (3.9 versus 3.3) and more effective for learning the methods (4.1 versus 3.4). Both of these differences are significant at $p \leq 0.05$.

Some additional questions were not directly part of this research project, but are nevertheless interesting. We compared the average number of exercises completed by each group, and for each test. The results are summarized in Table 12:

Table 12 - Average Number of Exercises Completed, by Group, for Each Test

Test 1		Test 2		Test 3	
Group A (WeBWorK)	2.0/3	Group A (Written)	2.5/4	Group A (WeBWorK)	2.5/3
				Group A (Written)	2.6/4
Group B (Written)	1.9/3	Group B (WeBWorK)	2.5/4	Group B (WeBWorK)	2.7/3
				Group B (Written)	2.7/4

One surprising observation is how consistent the results are between the two groups. In no instance did one group score significantly different in terms of the number of exercises completed. The conclusion is that students in this sample were no more likely to complete the WeBWorK exercises than they were to complete the written exercises. As has been mentioned before, the much stronger pattern is that students who are more likely to do the WeBWorK exercises are also more likely to do the written exercises.

The WeBWorK system allows instructors to follow student progress on each homework set assigned. We can see not only how many questions were answered correctly, but also, how many attempts it took to get the correct answer (see Appendix E, Figure 7). A review of this data in WeBWorK shows that most students are willing to make repeated attempts on a question until they get the correct answer. In fact, some students re-attempted a problem 10, 20, 30, and even 75 times. This supports the hypothesis that the immediate feedback feature of WeBWorK does encourage students to re-try a problem that they do not get correct on the first attempt. However, while this suggests that some students seem to be more tenacious when doing the WeBWorK problems, it raises doubts as to how effectively they are trying to learn the material. It may be the case that they are simply guessing, which is not an effective learning strategy. One can also assume that the motivational factor which derives from self-

efficacy, a sense of control, and feeling competent must also be completely erased after such a large number of unsuccessful attempts.

Unfortunately, we do not know how many times a student tries and re-tries on the written exercises.

CHAPTER 6: DISCUSSION AND CONCLUSIONS

1 DISCUSSION OF MAIN RESULTS

This research project measured and analyzed the effects of using WeBWorK exercises on students' academic performance in two Quantitative Methods classes at Vanier College. It also explored students' perceptions of the WeBWorK and written exercises. The general research question was:

How do WeBWorK exercises affect the student learning process and outcomes in the Quantitative Methods course in the Social Science program?

A review of the literature revealed three themes related to the research question. Each of these themes then generated a secondary research question. The first theme reflected the impact of online exercises on academic performance. Several previous studies found significant positive differences between groups of students who used an online homework system, such as WeBWorK, compared to students who did written exercises instead. In the current study, we tried to replicate these findings in the QM course. We measured whether students who did WeBWorK exercises would get significantly higher grades than students who did written exercises. A crossover design was used in order to compare whether the group that did WeBWorK problems during one unit would score significantly higher on that unit test than the other group that did the written problems.

We did not find a significant difference. The grades on each test were not significantly affected by whether the group did the written, WeBWorK, or both kinds of exercises. In this sample, there was no difference in grades between students who did the WeBWorK exercises and students who did the written exercises.

We also tested the hypothesis that students who complete more of the WeBWorK exercises will get significantly higher grades than students who complete

fewer of the WeBWorK exercises. The straight-line relationship between number of WeBWorK exercises completed and grades was positive in both groups. However, the correlation coefficients for these two variables showed no real pattern. On Test 1, students in Group A who completed more of the WeBWorK exercises scored significantly higher than students who completed fewer of the WeBWorK exercises. But students in Group B who completed more of the WeBWorK exercises did not score significantly higher on Test 2 than students who completed fewer of the WeBWorK exercises. Overall, doing more WeBWorK exercises was positively correlated with higher grades, but this relationship was neither strong nor consistently significant.

Our third research question was investigated by using a survey to elicit students' perceptions and opinions regarding the WeBWorK and written exercises. Students reported no difference in the amount of effort put into completing each type of exercise. While students claimed to have spent more time on the written exercises than on the WeBWorK exercises (42.9 minutes versus 34.3 minutes), this difference was not significant at $p \leq 0.05$.

Students were asked to rate each type of exercise along six dimensions and a composite score was calculated. Overall, students gave a significantly higher score to the written exercises ($p \leq 0.01$). Students reported that they found the written exercises were better for understanding the basic statistical concepts and for learning the basic statistical methods. However, and somewhat surprisingly, when presented with the choice of having only written or only WeBWorK exercises, the mean score for having only WeBWorK was slightly (but not significantly) higher, and slightly more students preferred or strongly preferred having only WeBWorK exercises.

2 CONCLUSIONS

Teaching statistics, especially in the 21st century, can be improved by using a variety of tools and methods at our disposal. For instructors who are comfortable with using technology in their teaching, WeBWorK offers many valuable advantages to

enhance student learning. As with all pedagogical innovations, the advantages of using WeBWorK to teach statistics are variable. Overall, in this project, we did not find any statistically significant differences in grades between students who used WeBWorK versus students who did written exercises.

One possible explanation for this surprising result is that the tests were always written, not done online. The written questions would sometimes ask for a specific calculation, but more often, these exercises took the form of problems, and more closely reflected the kinds of questions asked on the tests and on the final exam. Some of the WeBWorK questions quizzed students on the definitions of concepts, while others asked students to calculate and enter answers such as the value of a z-score or a margin of error. While these are necessary statistical skills, the fact is that the questions asked on the tests more closely reflected the written exercises than the WeBWorK questions. If the tests had been done online, with questions of the same format as those of the WeBWorK exercises, perhaps the correlation between doing the WeBWorK exercises and test results would have been more consistent and significant.

Many learning theories would predict that students would do better when using the WeBWorK system than when doing only written exercises because the WeBWorK system has several features that are related to positive learning outcomes. The immediate feedback is one advantage. The current study was set up so that WeBWorK offered immediate feedback in whether the answer is right or wrong, which is a kind of scaffolding, but the student did not receive any more feedback than this from the system. Conversely, while the feedback given on the written exercises was not immediate, it was more detailed, such as providing hints, suggestions, or asking guiding questions. This is a more elaborate kind of scaffolding, and may have served as a confounding factor in the present study.

While the correlations between the number of WeBWorK exercises completed and grades was generally positive, the differences were not consistently significant. In fact, and not surprisingly, the correlations between the number of written exercises and

grades was also positive, and more consistently so. The failure to find significant differences has a few possible explanations. The first is that the current study used a small sample. With small samples, one or two outliers can have a strong effect on the strength and even the direction of the correlation. Another reason may be that some students will do well on tests and the exam regardless of the number of exercises they complete. While this appears to contradict the premise of active learning theories that students learn better by doing exercises, this may not be the case. These students may be using other active learning strategies such as listening attentively in class and taking notes or completing the review tests which were given before each assessment.

The student survey revealed that student perceptions about the utility and enjoyment of doing the WeBWorK exercises was variable. Overall, students said that they found the written exercises to be more helpful than the WeBWorK exercises for undersanding the material. This may be a reflection of the fact that the feedback on the written material was more elaborate than the feedback obtained from the WeBWorK system. It may also be because the tests and the final exam were in the same format (written) as the written exercises.

3 LIMITATIONS OF THE STUDY

The primary focus of this study was to compare the effect of doing WeBWorK exercises on grades. We measured two types of comparison; between doing WeBWorK exercises versus doing written exercise (homework assignment effect), and between students who did more WeBWorK exercises versus students who did fewer WeBWorK exercises (homework completion effect). It was hypothesized that the immediate feedback and ability to re-do problems, characteristics of the WeBWorK system, would result in higher grades.

One limitation of this study was that we did not consider the impact of other kinds of feedback. It would be interesting to measure whether results would have been different if students had been given hints while doing the WeBWorK exercises. If this

study were replicated, it would be interesting to add the hints and suggestions to the WeBWorK problems and measure whether this would have a more significant impact on grades. Alternatively, in order to be comparable, the written exercises should have only given the same kind of feedback as the WeBWorK system, namely, only indicating whether an answer was right or wrong.

Another limitation is that the student survey mainly asked students about whether they thought that the WeBWorK or written exercises helped them to learn the course material. Unfortunately, we did not ask students to explain why they found one type of exercise better than the other. We also did not ask students to comment on the nature of the feedback they received.

While it is a question that is beyond the scope of this present study, it may be that WeBWorK is more beneficial than written exercises to some students, but not to all. The context in which the exercises were done was also presumably an important factor, but not one that was sufficiently considered in the present study. The immediate feedback feature of the WeBWorK system may be used more productively if students were to do the WeBWorK exercises in class. The system would immediately tell them whether their answer were right or wrong; if it were wrong, they could then seek additional guidance from the instructor before re-entering a new response.

A final limitation of this study is the small sample size. The general rule of thumb is to have a sample size of at least 30 because this is the point at which standard deviations and confidence intervals tend to become minimized and more stable. However, with groups this small, a few outliers can still have an important impact, reducing the likelihood of finding statistically significant results. While convenience samples were used, the two groups were found to be quite representative of the population of Social Science students at Vanier College. We collected data on gender and semester of study, as well as administering a math skills pre-test. There was no significant difference between the groups on any of these factors.

4 SUGGESTIONS FOR FURTHER RESEARCH

One suggestion for future study is to not only measure whether WeBWorK positively influences performance, but to examine how and why it may have a positive effect. Another suggestion, following from the first, would be to study in greater detail the impact of using more of the WeBWorK platform's features, such as offering students hints and suggestions. Additionally, the context in which WeBWorK is used most likely also has an impact on student learning. In this particular project, students were sometimes allowed to work on both the WeBWorK and the written exercises during class time. This allowed them to collaborate on the problems as well as ask the teacher for guidance (which they did). This most likely had an effect on student learning as well. Further research into this effect may show how WeBWorK may be used more effectively.

Unfortunately, the present study did not ask students to explain why they found one type of exercise better than the other. This may be a topic for further research. It may also be interesting to examine whether WeBWorK is more effective for certain kinds of students. Since the ability to re-try an incorrect question may have a positive impact on student motivation and self-regulation, perhaps students with greater math (or statistics) anxiety gained a greater benefit from using the WeBWorK system and got better grades than they would have if they only had written exercises to do.

The general conclusion of this research is that simply implementing the WeBWorK system is not enough, we also need to study and understand how it can be used to offer the greatest benefit. It is likely that the WeBWorK system is a valuable learning tool that can be used by interested instructors to enhance student learning of quantitative methods. What remains is to examine how this system can be implemented more effectively.

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APPENDIX A RESEARCH ETHICS BOARD APPROVAL LETTER

VANIER COLLEGE
RESEARCH ETHICS BOARD
RESEARCH CERTIFICATION

This is to certify that the Research Ethics Board of Vanier College has examined the research proposal by

Marc Belanger
name of applicant(s)

entitled __The Effects of Using WeBWorks Exercises in a Quantitative Methods Course_____
title of project

Ethics approval is granted for a period of one year from the date of this approval. After that date, all research must cease unless an application for renewal has been approved. A final report summarizing the findings of the study should be submitted to the Vanier College Research Office within six months of study completion.

RESEARCH ETHICS BOARD MEMBERS

Marc Belanger- Chairperson

James Pan

Allan Insealey

Kelly Purdy

Karen White

May 14, 2014
Date

Kelly Purdy *on behalf of the Research Ethics Board*

APPENDIX B CONSENT FORM FOR STUDENT PARTICIPATION

CONSENT TO PARTICIPATE IN RESEARCH

The Effects of Using WeBWorK Exercises in the Quantitative Methods Course

You are asked to consent to participate in a research study conducted by Marc Belanger from the Social Sciences Department at Vanier College.

PURPOSE OF THE STUDY
This research project will examine and analyse the effects of using WeBWorK exercises on students' grades and the number of exercises they do in the Quantitative Methods course in the Social Science program at Vanier College. In addition, a qualitative description of students' perception of the exercises as well as greater information on their motivation to do the exercises will also be made.

PROCEDURES
A quasi-experiment has been set up using two QM classes. Each class will alternate using WeBWorK and pencil-and-paper exercises. Exercises are already an instructional strategy used by many QM teachers. All we are requesting is your consent to include your performance in the class (your final grade) and the number of exercises you complete throughout the semester as part of the overall data for the study. You will also be asked to complete a brief questionnaire regarding your perception of the exercises.

POTENTIAL RISKS AND DISCOMFORTS
There are no known harms associated with your participation in this research. The only potential risk is that one method may result in greater learning outcomes than the other. However, by alternating methods throughout the semester, there should be no advantage or disadvantage to being in either of the two classes.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY
This research hopes to identify and describe the potential benefits of using WeBWorK exercises in a QM class, and could help direct pedagogical development at Vanier and other institutions in the future.

CONFIDENTIALITY
Confidentiality will be respected. No information that discloses your identity will be released or published without your specific consent. Your data will be provided only to the researcher (Marc Belanger) who will conduct the relevant analyses. Once completed, any information obtained beyond regular grades (stored in Omnivox) will be deleted.

PARTICIPATION AND WITHDRAWAL
You can choose whether to be in this study or not. In particular, you may exercise the option of not including your data in the study, or of withdrawing your information at any point up to the last day of the semester (December 9, 2014), with no negative consequences. You may also refuse to answer any questions you don't want to answer from the questionnaire and still remain in the study.

RIGHTS OF RESEARCH PARTICIPANTS
Participation in research must be voluntary. If you choose not to participate, you will continue to have access to quality education. If you choose to participate and later decide to change your mind, you can say no and stop your participation at any time. Again, you will

continue to have access to quality education. This study has been reviewed and received clearance through the Vanier College Research Ethics Board. If you have questions regarding your rights as a research participant, contact:

Caroline Hanrahan
Coordinator, Institutional Development & Research Office
Vanier College, 821 Ste. Croix, Montreal, Quebec, H4L 3X9

SIGNATURE OF RESEARCH PARTICIPANT

I have read the information provided for the study "The Effects of Using WeBWorK Exercises in the Quantitative Methods Course" as described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

_____
Name of Participant (please print)

_____ _____
Signature of Participant Date

APPENDIX C SURVEY ON QUANTITATIVE METHODS EXERCISES

Survey on Quantitative Methods Exercises

This questionnaire is part of a study currently being conducted by Marc Belanger to compare the effectiveness of different instructional strategies in the Quantitative Methods course. Please answer every question honestly and to the best of your ability. Your responses are completely confidential, and your teacher will not see these surveys until after the final grades have been submitted.

Please note that you are not obliged to complete the survey. You are also not obliged to answer every question. If you do not wish to participate, simply return the blank questionnaire to the instructor when all the surveys are collected.

Demographics

1. Please answer the following questions about yourself:

   a) Gender: _____

   b) Semester of study in CÉGEP: 1 2 3 4 5 6 Other: _____

Completing the Exercises

a) In this course, you were assigned several **written exercises**.
How many of these did you complete? _____

b) In this course you were assigned several **WeBWorK problem sets**.
How many of these did you complete? _____

c) Estimate the average **amount of time** you spent completing one of the **written** assignments: _____ minutes

d) Estimate the average **amount of time** you spent completing one of the **WeBWorK** problem sets: _____ minutes

e) On a scale of 1-5, where 1 is no effort at all, 3 is the perfect amount of effort, and 5 is far too much effort, indicate the **amount of effort** you feel you put in to completing the **written** assignments.

1 2 3 4 5

No Effort Perfect Too Much

f) On a scale of 1-5, where 1 is no effort at all, 3 is the perfect amount of effort, and 5 is far too much effort, indicate the **amount of effort** you feel you put in to completing the **WeBWorK** problem sets.

1 2 3 4 5

No Effort Perfect Too Much

g) On a scale of 1-5, where 1 is not at all and 5 is very much, indicate how much you felt doing the **written** exercises helped you to **learn** the course material.

1 2 3 4 5

Not at all Very much

h) On a scale of 1-5, where 1 is not at all and 5 is very much, indicate how much you felt doing the **WeBWorK** problem sets helped you to **learn** the course material.

1	2	3	4	5
Not at all				Very much

Effectiveness of the Exercises

On a scale of 1-5, where 1 is totally disagree and 5 is completely agree, rate your level of agreement with the following statements:

	Disagree				Agree
a) The **WeBWorK** exercises were clear and easy to understand.	1	2	3	4	5
b) I enjoyed doing the **written** exercises.	1	2	3	4	5
c) The **written** exercises helped me to better understand the course material.	1	2	3	4	5
d) The **WeBWorK** exercises were difficult to follow and confusing.	1	2	3	4	5
e) The **WeBWorK** exercises helped me to better understand the course material.	1	2	3	4	5
f) The **written** exercises were difficult to follow and confusing.	1	2	3	4	5
g) I enjoyed doing the **WeBWorK** exercises.	1	2	3	4	5
h) The **written** exercises did not help me to learn the course material.	1	2	3	4	5
i) The **WeBWorK** exercises were boring to do.	1	2	3	4	5
j) The **written** exercises were clear and easy to understand.	1	2	3	4	5
k) The **WeBWorK** exercises did not help me to learn the course material.	1	2	3	4	5
l) The **written** exercises were boring to do.	1	2	3	4	5

Comparison of the Exercises

a) On a scale of 1-5, where 1 is not at all prefer and 5 is very much prefer, indicate how much you would have preferred having **only written** exercises to do.

1 2 3 4 5

Not prefer Much prefer

b) On a scale of 1-5, where 1 is not at all prefer and 5 is very much prefer, indicate how much you would have preferred having **only WeBWorK** exercises to do.

1 2 3 4 5

Not prefer Much prefer

c) On a scale of 1-5, where 1 is not at all effective and 5 is much more effective, indicate how much the **WeBWorK** exercises helped you understand the basic **statistical concepts**.

1 2 3 4 5

Not Effective More Effective

d) On a scale of 1-5, where 1 is not at all effective and 5 is much more effective, indicate how much the **written** exercises helped you understand the basic **statistical concepts**.

1 2 3 4 5

Not Effective More Effective

e) On a scale of 1-5, where 1 is not at all effective and 5 is much more effective, indicate how much the **written** exercises helped you learn the basic **statistical methods**.

1 2 3 4 5

Not Effective More Effective

f) On a scale of 1-5, where 1 is not at all effective and 5 is much more effective, indicate how much the **WeBWorK** exercises helped you learn the basic **statistical methods**.

1 2 3 4 5

Not Effective More Effective

Thank you for your efforts in completing this survey honestly and to the best of your ability.

APPENDIX D ADDITIONAL TABLES AND STATISTICAL RESULTS

Table 13 - Protocol for the Crossover Design by Topic and Exercise Type

	Topic	Group A	Group B
Module 1	Variables	WeBWorK	Written
	Central Tendency	WeBWorK	Written
	Displaying Data	WeBWorK	Written
Module 2	Samples	Written	WeBWorK
	Z-scores	Written	WeBWorK
	Confidence Statements	Written	WeBWorK
	Hypothesis Tests	Written	WeBWorK
Module 3	Correlation	WeBWorK & Written	WeBWorK & Written
	Regression	WeBWorK & Written	WeBWorK & Written
	Chi Square	WeBWorK & Written	WeBWorK & Written
	CPI	WeBWorK & Written	WeBWorK & Written

Table 14 - Independent Sample t-tests for Assessments

Assessment	Independent Sample t-test Results, two-tailed, $t(56)$
Test 1	The t-value is 0.057; the p-value is 0.9547 The result is not significant at $p < 0.05$
Test 2	The t-value is 0.354; the p-value is 0.7245 The result is not significant at $p < 0.05$
Test 3	The t-value is 0.511; the p-value is 0.6112 The result is not significant at $p < 0.05$
Final Exam	The t-value is 0.167; the p-value is 0.8680 The result is not significant at $p < 0.05$
Total (Tests + Exam)	The t-value is 0.341; the p-value is 0.7347 The result is not significant at $p < 0.05$

Table 15 - Independent Sample t-tests, Students Who Did All the Exercises

Assessment	Independent Sample t-test Results, two-tailed
Test 1	$t(24) = 0.791$; the p-value is 0.4363 The result is not significant at $p < 0.05$
Test 2	$t(18) = 0.067$; the p-value is 0.9476 The result is not significant at $p < 0.05$

APPENDIX E THE WEBWORK INTERFACE AND DATA

Students access the WeBWorK system by signing in with a username and password. They are then able to access the problem sets that have been assigned. The instructor can set an opening and closing date for each problem set.

In this course, each problem set was named after the topic, and each set had between ten and twelve questions. The following is an example of a WeBWorK question (Figure 4), and the response from the system for a correct answer (Figure 5) and for an incorrect answer (Figure 6).

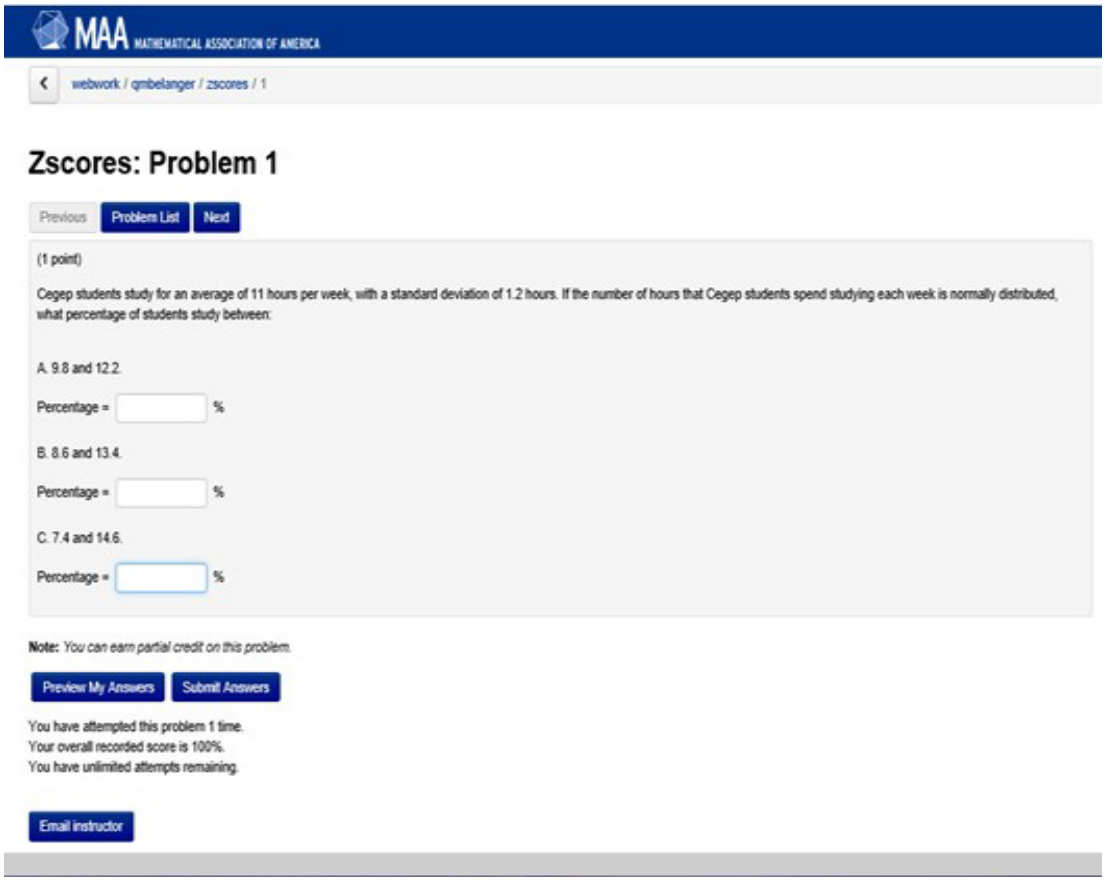


Figure 4 Example of a WeBWorK question

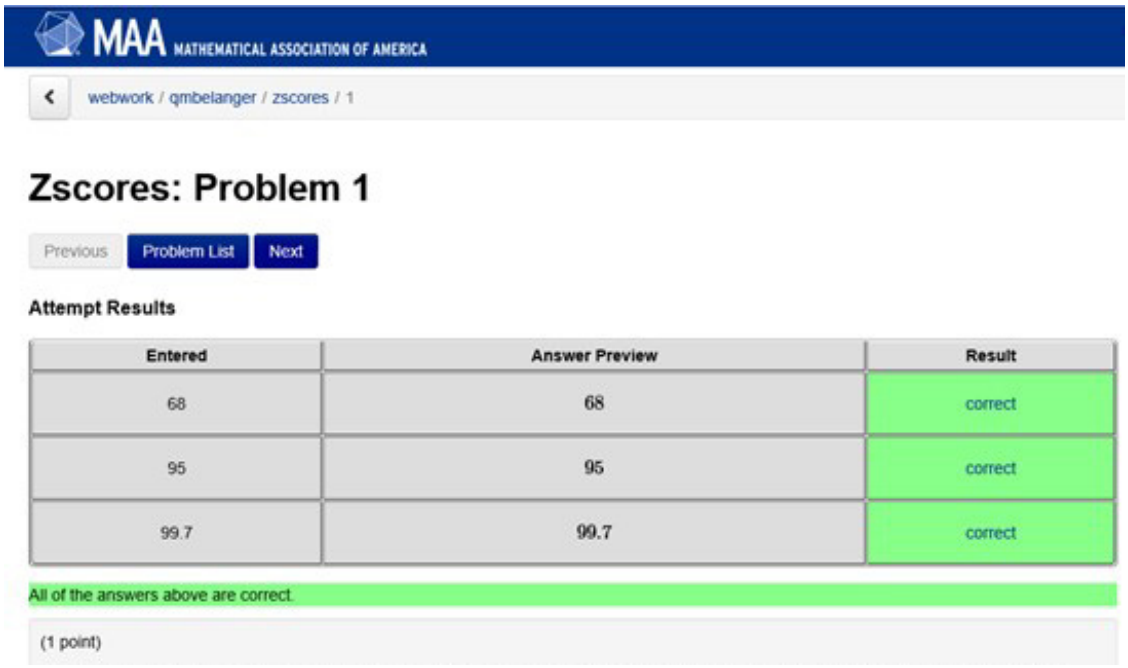


Figure 5 Example of Correct Responses and Feedback

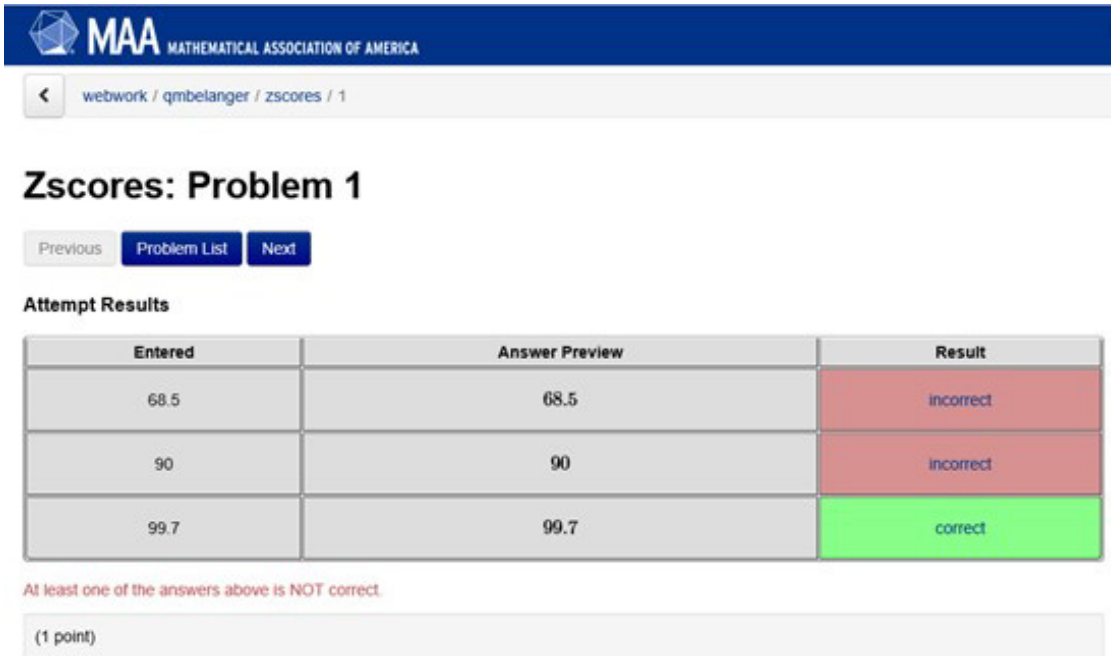
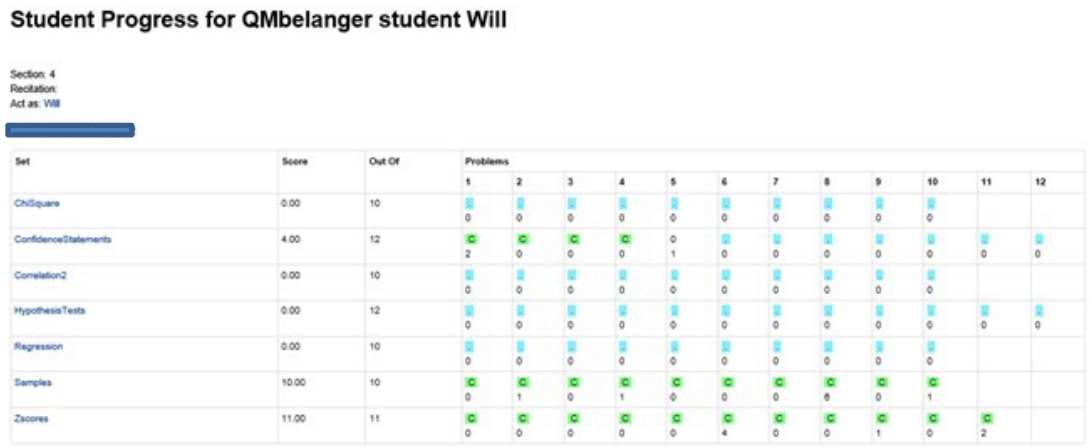


Figure 6 Example of Incorrect Responses and Feedback

An example of the progress report for a particular student is shown in Figure 7. This student only completed two problem sets (Samples and Z-Scores), and partially

attempted the problem set Confidence Statements. In the two sets that the student completed, he got all the questions correct, as indicated by the "C" in each column. We can also see that in the Samples problem set, he got the first question correct on the first attempt (0 re-tries), he got the second question correct on the second attempt (1 re-try), and on question 8, he tried 7 times (6 re-tries) before finally getting the correct answer.



Student Progress for QMbelanger student Will

Section: 4
Recitation:
Act as: Will

Set	Score	Out Of	Problems											
			1	2	3	4	5	6	7	8	9	10	11	12
ChiSquare	0.00	10	I 0	I 0	I 0	I 0	I 0	I 0	I 0	I 0	I 0	I 0		
ConfidenceStatements	4.00	12	C 2	C 0	C 0	C 0	0 1	I 0	I 0	I 0	I 0	I 0	I 0	I 0
Correlation2	0.00	10	I 0	I 0	I 0	I 0	I 0	I 0	I 0	I 0	I 0	I 0		
HypothesisTests	0.00	12	I 0	I 0	I 0	I 0	I 0	I 0	I 0	I 0	I 0	I 0	I 0	I 0
Regression	0.00	10	I 0	I 0	I 0	I 0	I 0	I 0	I 0	I 0	I 0	I 0		
Samples	10.00	10	C 0	C 1	C 0	C 1	C 0	C 0	C 0	C 6	C 0	C 1		
Zscores	11.00	11	C 0	C 0	C 0	C 0	C 0	C 4	C 0	C 0	C 1	C 0	C 2	

Figure 7 Example of Student Progress Report